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RTO West Market Design Work Group
Market Operations Task Team

White Paper – Load Zones
And Trading Hubs

Background:

The RTO West Stage 2 Proposal adopted a nodal pricing structure to facilitate congestion management. Under nodal pricing, congestion cost for a point-to-point schedule is defined as the difference in nodal prices between the point of injection and the point of withdrawal[1] times the number of transaction volume measured average MW for a given billing interval. While the calculation of the nodal prices is complex, the settlement of a point-to-point schedule is straightforward once the nodal clearing prices have been calculated.

Of course the majority of load service is not accomplished using point-to-point transmission service, but rather by using forms of network service[2]. Energy is scheduled from a set of injection points to a much larger set of withdrawal points. Such network schedules for larger entities many involve hundreds of delivery points, i.e., one for each substation bus where energy leaves the RTO West Controlled Transmission System. The RTO West Stage 2 Proposal anticipated the creation of "Load Zones" (or Zones) to simplify scheduling and settlement within a large system with as many as 3,000 nodes.

Over the past decade or so, trading hubs have developed in the industry to facilitate transactions. Hubs such as COB and Mid-C were created to provide an intermediate point between an ultimate source and an ultimate sink where energy trades could occur. Indices of transaction prices at hubs are now published daily in trade journals. As with Load Zones, the RTO West Stage 2 Proposal also anticipated the creation of "Trading Hubs" (or Hubs) to permit hub transactions to continue after RTO West begins to operate the transmission system.

Proposal:

<u>Load Zones</u>: RTO West will allow Scheduling Coordinators (i.e., transmission service customers or their agents) to create Load Zones that the Scheduling Coordinators may use to simplify scheduling and settlement. A Load Zone is a set of nodes identified by the customer at which energy is withdrawn from the system. Generator buses may not be included in a Load Zone definition. The Load Zone price is the load-weighted average of nodal prices for the defined set of nodes.

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[1] For the purpose of this paper, an injection point is equivalent to a Point of Receipt and a withdrawal point is the same as a Point of Delivery.
[2] Network service as used here refers to both formal network service arrangements under Order No. 888 tariffs or similar predecessors and to the implicit network service provided by a transmission owner's transmission system to serve its existing retail service obligations.

Trading Hubs: After consulting with its customers, RTO West will create trading hubs that any Scheduling Coordinator may use as an intermediate trading point for energy transactions with other Scheduling Coordinators. The Trading Hub will be defined by an identified set of nodes posted on OASIS and will be selected based on input from customers to meet the needs of the wholesale power market. The Trading Hub prices will be the weighted average price of the nodal prices of the set of nodes used to define the Trading Hub. The average will be calculated using a set of fixed weights posted on OASIS.

Working Assumptions:

Nodal prices will be calculated and posted for all nodes in the RTO West Transmission System. The posting of Load Zones and Trading Hub prices will be additional information provided by RTO West as a supplement to, not a replacement for, individual nodal prices.

Discussion:

Approaches to Simplification

One of the early criticisms of nodal pricing structures is their complexity. Since each substation bus is a node of the transmission network, whenever there is congestion in the network, there will be thousands of prices for a network the size of the RTO West transmission system. Without a simplification of some kind, both scheduling, trading and settlement would be exceedingly complex. Efforts to effect a simplification have taken two different routes: (1) simplification of the network model used for congestion management; and (2) simplification of prices generated by a full network model.

California's original model, the ERCOT model, RTO West's Stage 1 model all used the first approach. A limited number of physical zones were defined with the assumption that there was little internal congestion within the zone. A limited number of ties (or flow gates) were recognized between the physical zones where the majority of congestion was expected to occur. To the extent that congestion occurred within these physical zones, there was a mismatch between the network operators cost of controlling congestion and the charges it made to customer for congestion cost. This mismatch, or residual congestion, was a known problem. It turned out to be much more significant than the proponents of this simplification approach expected.

When PJM initiated nodal pricing in 1998, they adopted the second approach to simplification. Rather than simplify the network, PJM used a full network model and created prices at every node in the system. PJM then made mathematical aggregations of the nodal prices to simplify price reporting and settlements. By using weighted averages for these aggregations, they avoided creating any residual congestion. Settlement at the aggregation prices is equivalent to settlement at nodal prices. The trading hubs have proven to be very useful, particularly the PJM West Hub, the most liquid and heavily traded of US trading hubs.

The above proposal is based on the PJM model, using mathematical aggregation to zones and hubs from nodal prices. The same approach is also taken for Zones and Hubs in the Standard Market Design NOPR. This approach does not use any simplification of the network model, so there will be no residual congestion to deal with as there would have been had the Stage 1 model been adopted. The only common feature of this model and the current proposal for zone creation is the desire for simplification and the word “zone”.

Load Zones

As proposed above, the creation of Load Zones would be based upon customer request. No customer will be required to use Load Zones, rather it is an option offered by RTO West. A customer may continue to have all settlement conducted on a node by node basis. A customer's delivery nodes will not be included in a zone definition without its permission. The example show in Table No. 1 demonstrates the calculation of the zonal prices. In this example prices at the four nodes are similar to each other. The load weights are the fraction of the total load included in the zone definition. The upper portion of the table shows that node by node settlement produces $6,850. The second portion of the table shows that settling based on the zonal price and the zonal load produces the same value.

Table No. 1
Simple Load Zone with Similar Prices

			Nodal Settlement			
Node	Zone	Load MW	LMP	Nodal Revenue	Load Weight	Weight * Price
A	1	50	12.0	600	0.100	1.20
B	1	100	14.0	1,400	0.200	2.80
C	1	150	15.0	2,250	0.300	4.50
D	1	200	13.0	2,600	0.400	5.20
Zone	1	500		6,850		13.70

Zonal Settlement	
Zone Price	13.70
Zone Load	500
Zone Revenue	6,850

Some concern has been raised that dissimilar prices may produce a mismatch. Table No. 2 provides a second four node example in which prices vary widely. Even though there is 5 to 1 difference in nodal prices across the zone, the settlement value, $19,100, is the same for both nodal and zonal settlement. This in fact is a general case solution which can be derived by simple algebraic operations. The load weights would be derived from scheduled values for day-ahead settlement and from metering for real-time settlements. If the load data is required by node to calculate the load weighting factors, why bother with creation of Load Zones? There are two answers why a customer may wish to use a Load Zone. The first is related to scheduling and the second is related to tracking of results.

Table No. 2
Simple Load Zone with Dissimilar Prices

Nodal Settlement

Node	Zone	Load MW	LMP	Nodal Revenue	Load Weight	Weight * Price
A	1	50	12.0	600	0.100	1.20
B	1	100	25.0	2,500	0.200	5.00
C	1	150	40.0	6,000	0.300	12.00
D	1	200	50.0	10,000	0.400	20.00
Zone	1	500		19,100		38.20

Zonal Settlement

Zone Price	38.20
Zone Load	500
Zone Revenue	19,100

It is very difficult to accurately forecast load at a given bus, however, because of load diversity it possible to produce a reasonably accurate forecast for a set of buses in a given area with similar weather and other factors. By clustering such buses under a Load Zone definition, a Scheduling Coordinator could submit the total load for the Zone to RTO West along with an expected distribution of loads among the buses. The distribution of loads could be derived from historic studies and may be relatively stable. As weather changes and total load changes, a Scheduling Coordinator could change the total and leave the distribution in place. Such simplified scheduling would thus be much like today's practice of area to area scheduling, yet consistent with nodal pricing.

As a Scheduling Coordinator watches the changes in its Load Zone prices, it can see the net effect of prices on a single index value. The index value may be useful for various kinds of supply decisions – making resource adjustments in the forward market, estimating the value of a portfolio of transmission rights (CTRs & FTOs) or hedging price risk with contracts for differences, swaps, calls, etc. Because the results do not affect other customers, the choice to use or not use Load Zones can be left to individual customers. Further because the zonal prices are derived from nodal prices, if a new zone is created the historic nodal prices will generate the historic prices that would have been charged in the zone. If a zone is altered, the zone prices can be restated to provide an accurate index for applications like forecasting the value of FTOs or CTRs. Zones may also have applications to General Transfer Agreements or other load related aggregations.

Trading Hubs

A Trading Hub is also a mathematical aggregation of nodal prices for an identified set of nodes that can be treated as if it were a single point for scheduling and settlement. The Trading Hub is a supplemental node which facilitates trading against a single index price as if it were a physical location. All injections and withdrawals from nodes at the Trading Hub have the same nodal price, so there is no congestion cost for such trades. Congestion cost will exist between the Trading Hub and another node as the spread in price between the hub and the node. The same would be true between a Hub and a Zone.

Unlike the Load Zones, the definition of a Trading Hub will include generation buses and other points of injection, like points of interconnections. Further, because the output varies considerably for individual machines, a set of fixed weights is used for calculating hub prices. The example show in Table No. 3 below illustrates the calculation and use of Trading Hubs. In this eleven node example, four nodes (I, J, K and L) are used to calculated the price for Hub á. As in Table Nos. 1 and 2, the Nodal settlement is shown in the upper block. Net nodal revenue is $500 which represents a net surplus from congestion clearing. Two different weighted prices are calculated. In the first method, fixed weights are used, with equal value being given to each nodal price. In the second method, input weights are used for the generators, the analog of load weighting.

Settlement using Hub prices is portrayed in the next portion of the table with the fixed weighted prices being used on the left and the input weighted prices used on the right. The schedules of three Scheduling Coordinators (SCs) are shown. The same schedules are shown in both the left and right tables. SC1 shows an injection of 1100 MW at Hub á, which it schedules for delivery (withdrawal) at nodes A, B and C. SC2 schedules a withdrawal of 300 MW at Hub á, i.e., it sold 300 MW to another party for delivery at Hub á. Finally SC3 scheduled a delivery of 800 MW at Hub á. The small tables below the settlement tables show that the sum of schedules into and out of the Hub add to zero. This must occur because Hub á is not a physical location but only an intermediate point used for pricing and the reconciliation of trade. In order to be able to "check out" schedules , some kind of tagging must be done by the SC's to enable RTO West to identify the source of mismatches in SC to SC trades at hubs.

Note that the net results of hub settlements with either fixed weighted or input weighted prices are the same – $500. This is the same result obtained from nodal settlements. For RTO West, the choice of weighting factors has no impact on total collection. Because the trades at the hub sum to zero and all occur at the same price RTO West is unaffected by the method used. This is not true for the SCs. Because different hub prices are produced, the congestion cost between a node and the hub will change depending on method. As long as the method is known in advance, and a price history is available for the hub, the SCs will factor this into their decisions for forward trades to be delivered at the hub. After some discussion, the MDWG arrived at a tentative conclusion that fixed weights should be used as they are in PJM and as proposed in FERC's SMD NOPR. By using fixed weights, variance in output levels will not contribute to volatility in the Trading Hub prices.

One of the more important questions to be addressed with regard to Trading Hubs is the selection of nodes to be included in the definition of a Trading Hub. RTO West should work with its customers to determine the number of hubs and locations which the customers will find useful. However, because the hub prices will be used by multiple parties, RTO West should make the final determination of nodes to include. In making that decision, RTO West should consider the similarity of price behavior for the set of nodes proposed. Do prices at these nodes move together? Is the price spread between the buses small (i.e., is minimal congestion among a set of nodes over time)? The experience of PJM in this regard is of interest. The PJM West Hub has little price dispersion among nodes with minimal volatility. This has attracted a great deal of trade to the West Hub. By contrast the PJM East Hub price has been erratic, which seems to be traceable to the fact that price movement among the East Hub notes is dissimilar due to substantial congestion within the East Hub node.

The initial formation of trading hubs in RTO West could be informed by experience at COB and Mid-C, both of which are obvious candidates for RTO West Trading Hubs. Creation of other hubs later can be guided by nodal price data as it accumulates. Because the Hub prices are mathematical aggregations, the "historic" values for a new hub or for a change in hub definition can be calculated. Additionally, the old definition can be left in place if there are parties who may still be using it as in index in a continuing contract. In addition to aiding prediction of future trading value, Trading hubs may be useful for dealing with issues like those that arise in connection with PNCA or MCHCA.

Table No. 3
Trading Hub Example

Nodal Settlement

Node	Hub	Gen (Load)	LMP	Nodal Revenue	Fixed Weight	Fixed Wt * Price	Input Weight	Input Wt * Price
A		(200)	19.0	3,800				
B		(400)	20.0	8,000				
C		(500)	21.0	10,500				
D		(200)	23.0	4,600				
E		(200)	40.0	8,000				
I	á	100	12.0	-1,200	0.25	3.00	0.1	1.20
J	á	200	14.0	-2,800	0.25	3.50	0.2	2.80
K	á	300	18.0	-5,400	0.25	4.50	0.3	5.40
L	á	400	20.0	-8,000	0.25	5.00	0.4	8.00
M	-	200	25.0	-5,000				
N	-	300	40.0	-12,000				
Gen/Load Balance		0						
Net Congestion Cost				500				
Hub	á					16.0		17.4

Settlement w/Hub Schedules -- Fixed Weighted

	Location	Inj (Wthd)	LMP	Rev
SC1	á	1100	16.0	-17,600
	A	(200)	19.0	3,800
	B	(400)	20.0	8,000
	C	(500)	21.0	10,500
Gen/Load Balance		0		
Congestion Cost				4,700
	Location	Inj (Wthd)	LMP	Rev
SC2	I	100	12.0	-1,200
	J	200	14.0	-2,800
	M	200	25.0	-5,000
	á	(300)	16.00	4,800
	D	(200)	23.0	4,600
Gen/Load Balance		0		
Congestion Cost				400
	Location	Inj (Wthd)	LMP	Rev
SC3*	K	300	18.0	-5,400
	L	400	20.0	-8,000
	N	300	40.0	-12,000
	á	(800)	16.0	12,800
	E	(200)	40.0	8,000
Gen/Load Balance		0		
Congestion Cost				-4,600
Net Cong Cost				500

Settlement w/Hub Schedules -- Input Weighted

	Location	Inj (Wthd)	LMP	Rev
SC1	á	1100	17.4	-19,140
	A	(200)	19.0	3,800
	B	(400)	20.0	8,000
	C	(500)	21.0	10,500
Gen/Load Balance		0		
Congestion Cost				3,160
	Location	Inj (Wthd)	LMP	Rev
SC2	I	100	12.0	-1,200
	J	200	14.0	-2,800
	M	200	25.0	-5,000
	á	(300)	17.40	5,220
	D	(200)	23.0	4,600
Gen/Load Balance		0		
Congestion Cost				820
	Location	Inj (Wthd)	LMP	Rev
SC3	K	300	18.0	-5,400
	L	400	20.0	-8,000
	N	300	40.0	-12,000
	á	(800)	17.4	13,920
	E	(200)	40.0	8,000
Gen/Load Balance		0		
Congestion Cost				-3,480
Net Cong Cost				500

Hub Activity

	Inj (Wthd)	LMP	Rev
Hub Receipts			
SC2 to Hub	300	16.0	4,800
SC3 to Hub	800	16.0	12,800
Hub Deliveries			
Hub to SC1	(1100)	16.0	-17,600
Hub Trade Balance	0		0

Hub Activity

	Inj (Wthd)	LMP	Rev
Hub Receipts			
SC2 to Hub	300	17.4	5,220
SC3 to Hub	800	17.4	13,920
Hub Deliveries			
Hub to SC1	(1100)	17.4	-19,140
Hub Trade Balance	0		0

Note: * SC3 is delivering 800 MW to Hub á. 700 MW is from nodes K & L, which are part of the hub definition, 100 MW from N which is not included in the hub definition. Use of the hub as a trading point does not depend upon being part of the definition used to calculate the hub price.